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AN OVERVIEW OF ENERGY RESOURCES UTILIZATION AND ITS ENVIRONMENTAL AND HEALTH IMPACTS

Aika A. T[1]., Igbinovia S. O[2]., Osayi F. S[3]. and Aibangbee J. O.[4]

[1, 2] Department of Electrical/Electronic Engineering, Faculty of Engineering, University of Benin, Benin City, Nigeria.
[3]Department of Electrical/Electronic Engineering, School of Engineering, Auchi Polytechnic, Auchi, Edo State, Nigeria.
[4]Department of Electrical/Electronic and Computer Engineering, College of Engineering and Technology, Bells University of Technology, Benja Village, Ota, Ogun State, Nigeria.

Abstract

Energy in any of its of its form is the propelling force that drives human and manmade systems, and then makes the world nations to be classified technologically, economically and socially developed or underdeveloped. In this way energy is an idea, an intellectual concept that stands out in the history of modern scientific and engineering thought [1]. Energy in its raw state and converted to other forms of desired energies is usually associated with rejected wastes that has over decades altered the environmental conditions to a great concern of this days global warming. Out of the four major use of energy in socioeconomic, namely: residential and commercial; transportation; industrial and electrical power generation, this study is focused on electrical energy generation and its environment (pollution) effects. The study revealed that all types of power plants rejects waste energy at different levels that are harmful to human beings, aquatic lives, habitat, air, water etc. Total energy or integrated modular systems combined processing plants called Cogeneration or Combined Cycle systems is one the techniques that conserves energy resources and enhances the overall fuel utilization efficiency, typically from 70-80% versus 35-40% for utility power plants. The study also reveals recent happenings in the world, which depicts facts that as the world's energy market changes a distribution of economic wealth occurs and that the impact of energy and economic is felt in unemployment, Gross Domestic Product (GDP) and Gross National Product (GNP) indices, inflation and trade [1] in nations. The availability of energy resources, technological knowhow, existing market policies, pertinent regulations, adequate organization and control of the energy and its pollutant level depicts the growing demands of increasing developmental growth without compromising socio-political, economic and environmental cost/issues in the nation.

1.0 INTRODUCTION

Energy in all form is the propelling force that drives human and man-made systems and makes nations to be classified as technologically, socially and economically developed or underdeveloped. Energy is not only a commodity; it is also an idea, an intellectual concept that stands out in the history of modern scientific and engineering thought [1].The affluence of a society or a nation is determined by its per capital Gross National Product and the per capital energy consumption[1, 2]. Guaranteeing a sustainable supply of affordable energy is one of the best ways to address POVERTY, INEQUALITY AND ENVIRONMENTAL DEGRADATION in every way on the planet [3].Representing this operation of average standard of living, L, for a nation with a mathematical model, we have[1];

$$L = \frac{R\ X\ E\ X\ C}{P} \quad (1)$$

Where,
R; represents the consumption of raw material
E; represents the Consumption of energy
C; represents consumption of all forms of ingenuity
P; represents the Population of the nation.

Energy use per capital of some nations presented in Table 1 [3] tied to the affluence of the population drops during economic slowdown, and as population stabilizes, the average level of affluence and well-being may stabilize, as long as a stable supply of energy and raw materials is available [1]. Nigeria non-conventional and conventional energy resources, the optional domestic primary energy consumption (percent of total),and indices in macro-economic performance are as presented in Tables 2 to 5 respectively [3].

Corresponding Author**:** Igbinovia S.O., Email: Samuel.igbinovia@uniben.edu, Tel: +2348051478161, +2348021473043

Table 1: Energy Consumption Per capita

S/N	Country	kWh/capita
1	U.S.A	12,711
2	Senegal	95
3	Cote D'Ivoire	139
4	Ghana	346
5	Nigeria	168

Source: [4].

Table 2: Nigeria's Non-Conventional Energy Resources

Resources	Reserves	Reserves (billion-toe)
Fuel wood	43.3 Million Tonnes / year	1.645 (over 100 years)
Animal waste and crop residue	144 Million Tonnes/year	3.024 (over 100 years)
Small scale hydro- power	734.2MW	0.143 (over 100 years)
Solar radiation	1.0kW per m^2 land area (peak)	-
Wind	2.0 - 4.0m/s	-

Source: PP155 of [3].

Note: 1000kWhr Primary energy = 0.223 toe; 1 tonne of Fuel wood = 0.38 toe
1 tonne of Agricultural waste = 0.28 toe; 1 tonne of Dung cakes = 0.21 toe

Table 3: Nigeria Conventional Energy Sources

Resources	Reserves	Reserves in Energy Units (billion-toe)	% Total Conventional Energy
Crude oil	23 billion barrels	3.128	21.0
Natural gas	4.293 billion m^3	3.679	24.8
Coal and lignite	2.7 billion tonnes	1.882	12.7
Tar sands	31 billion barrels of oil equivalent	4.216	28.4
Hydropower	10,000MW	1.9459(100 years)	13.1
Nuclear	-	-	-
Total	Conventional/commercial energy resources	14.859	100%

Source: PP154 of [3].

Note: Toe = Tonnes of oil equivalent; 1 barrel of oi l = 0.13 tonnes of oil; $1000m^3$ of Natural gas = 0.857 toe; 1 tonne of Coal = 0.697 toe; 1000kmhr (primary energy) = 0.223 toe

Table:4 Optimal Domestic Primary Energy Consumption (Percent of Total)

Year	Oil	Coal	Gas	Hydro	Fuel-Wood
1985	31.2	0.5	8.6	4.0	55.7
1990	39.4	1.1	18.0	5.1.	36.4
1995	32.0	1.6.	35.5	3.8	27.1
2000	31.9	2.9	37.1	3.5	24.6
2005	31.1	4.6	39.6	3.1	21.6
2010	30.3	6.9	42.0	2.0	18.9

Source: PP153 of [3].

Table 5: Macro-Economic Performances Index of Nigeria

S/N	Indicators	1998	1999	2000
1	Real GDP Growth Rate	2.4	2.7	2.8
2	Real GDP Target Rate	-	-	3.0
3	Growth Rate of Per Capita Income	(0.5)	(0.1)	0.1
4	Growth Rate of Agricultural Value-Added	3.5	3.7	3.3
5	Growth Rate of Industrial Value-Added	(4.7)	(1.4)	(0.8)
6	Capacity Utilization	32.4	32.0	30.0
7	Unemployment Rate	3.0	3.3	4.0
8	Inflation Rate	10.2	7.6	5.4

Source: [5].

From Tables 2 to 4, it is evident that the utilization of any form of energy resources in the industries, transportation (highway vehicles, air, marine rail), commercial and domestic sectors and electric power generation depends on its availability and time factor. Though several energy resources potential is abundantly high in Nigeria, still there exist dipped energy crises resulting in total dependence in their importation with 90% major inputs in power generation[6].According to[7, 8, 9] the major reasons for energy crises include the inability of the power sector to diversify its energy sources from hydro to thermal others in time, the menace of vandilisation of the gas pipelines and other power infrastructures by hoodlums, thieves, militants and terrorist, poor maintenance culture and poor power system reliability. This has led to the low index values of the nation's Gross Domestic Product (GDP) and Gross National Product (GNP) presented in Table 5 indicating low degree of industrialization and this motivated Nigeria government to construct her first power generating station in Lagos as far back as 1896, fifteen years after its introduction in England[10]. Hence the urgent need to improve in electricity generation and wheeling of power of the nation and then study the pollutant consequences and mitigate measures to meet the growing demands of increasing urbanized and industrialized economics without incurring unacceptable social, economic and environmental cost [6]. Thus depending on nations technology, economic and policies, siting and layout of generating stations sources of electricity the foremost impetus for all energy products: Like Thermal Power Station (which uses solid fuels); Diesel Power Stations (which uses isotopes of Uranium); Hydro-electric stations (which uses water-fall); Wind (average wind speed) and Oceans (tide) stations are constructed. Their planning and design without due consideration to problems of energy distribution, dwindling fossil-fuel supplies, instability in firm capacity of say hydro-schemes and environmental (pollution) and health effects, to mention a few impacts results in poor economic, political issues and descent society.

Implementing power stations that generates electricity from natural energy resources, two main statutory duties imposed upon the governing board or authorities are [11]:

1. To develop and maintain an efficient, coordinated and economic system of electricity supply.
2. To take into account the environmental effect, that is consider any effect which its proposals would have on the natural beauty of the country side and on flora, fauna, features, buildings and objects of special interest.

In this study section two presents energy resources and its conversion process. Section three look at pollution level and its characteristics effect and techniques for reducing pollution. In section four energy and economy issues is presented. Section five concludes the study. While the references that gave the background and understanding of this study is in section six.

2.0ENERGY RESOURCES AND CONVERSION PROCESS

Resources of energy employed in the production of electricity and rejected energy in the world are[1, 12]:1) Fossile fuels (heavy oil, natural gas, coal, etc.); 2)Nuclear fission and fusion; 3)Biomass fuel systems (waste, wood, algae and plants e.g. tropical grasses, water hyacinths etc.); 4)Solar radiation; 5)Geo-thermal; 6)Magneto hydrodynamics(MHD); 7)Fuel cells; 8)Wind; 9)Ocean tides and streams currents; 10)Hydro; and 11)Natural thermal gradients;12)Thermionic and thermo-electric generation (terrestrial heat).

Fossil-fuel, Water, Nuclear and Solar heat, and Coal, Wind and Tidal are the mostly used for electric power generation and the end product from some of these resources can be stored in the following forms;1) Pumped-storage Concept; 2) Hydrogen as a storage material; 3) Storage batteries;4) Compressed air storage system, and 5) Inertia-energy storage system e.g. flywheel

Figure 1 illustrate how energy is used by fuel and its relative percentage for industrial facility energy audit[13]. The energy audit process for a building emphasizes building envelope, heating and ventilation, air conditioning, plus lighting functions.

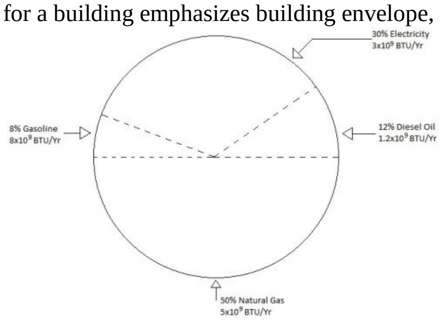

Figure 1: Energy use profile [13].

Energy is anything that makes it possible to do work [14]. Energy is also a property of matter and takes many form as show in Table 6[1]. Depending on the energy resources converted standard conversion factors are applied in energy engineering [13].

Table 6: Forms of Energy

Kinetic	Light	Sound
Electrical	Potential	Mass
Heat	Magnetic	
Nuclear	Chemical	

The process of converting any form of these energies to another is called “energy conversion”. The study of changes of energy and the transportation of energy from one place to another is called “thermodynamics”. All formof energy is converted within theboundary no matter the energy system. The law of conservation of energy often called the first law of thermodynamics applies to all system and is expressed as[1, 13]:

$$E_{in} = E_{out} + \Delta E_{stored} \quad (2)$$

In a standard electric power generating station, shown in Figure 2, the energy rejected or waste, E_R is:

$$E_R = (I - \mu)\, E_{in} \text{ in Joules} \quad (3)$$

Where, E_{in}; input energy to the system, power plant in this case

E_{out}; output energy from the system, that produced electricity in this case, Joules

ΔE_{stored}; stored energy in the system, Joules

μ; plant turbine efficiency

The overall efficiency of a typical electric power plant is approximately 33%, expressed as:

$$\eta = \frac{E_{electric}}{E_{fuel}} (4)$$

Indicating two-thirds of the fuel energy is lost in the stack output or cooling-water output.

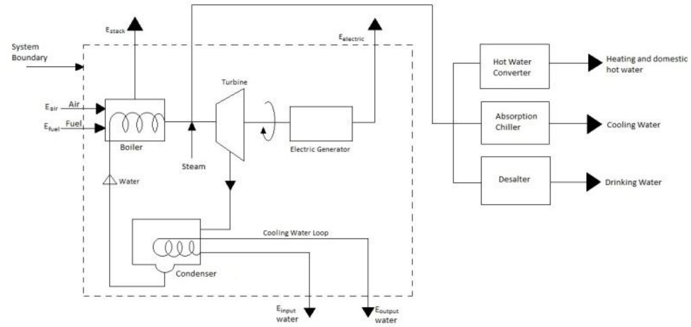

Figure 2: An electrical generating plant uses a steam turbine to drive the generator and a condenser to return the waste steam to water (i. e. a total energy system).

Total energy or integrated utility systems illustrated in Figure 2 is a combined processing plants often called cogeneration system [1]that provides the five necessary utility services for community development; electricity; environmental conditioning, solid-waste processing; liquid-waste process, and domestic water. The energy rejected in a co-generation process is recovered and then used to generate the second form of energy. Depending on the planning and design engineers' ability to utilize rejected heat waste, the overall fuel utilization efficiency of co-generation plant is typically 70-80% verse 35-40% for utility power plant[13].However, the process of compensating for environment as a result of extensive use of energy resources that includes recycling of materials, rapid transit, sewage treatment, air-pollution control equipment often consumes additional energy and thus increase our total use of energy[1].In this-wise the objectives of any total energy system are[1]; 1) Conserve natural resources; 2) Reduce energy consumption;3) Minimize environmental impact; 4) Be installed on a schedule consistent with development or redevelopment of a community;5) Eliminate impact of local restrictions on waste treatment which act as hindrance to the construction of housing schemes;6) Provide a transportable system for emergency operations (flood relief, earth quake etc.); and 7)Reduce total cost to the nation. The conservation of energy resources employs any of the following method; 1) Elimination of waste; 2) Shifting to less energy-intensive process; 3) Reduction of energy-consumption activities, and 4) Improving efficiency of energy – consumption activities.

Thus with a total energy system, one can achieve a savings of energy and thus reduce operating lost and lessen environmental pollution [15, 16]. The heat exhausted into the environment is sometimes called thermal waste or thermal pollution. Thermal pollution is the inevitable concomitant of power generation and cannot be eliminated. Heat exhausted into water is a serious problem because of its effect on aquatic life. In large urban areas, heat exhausted into the atmosphere may also be of significance because of its effect on local weather. In the case of mini/micro hydro schemes this adverse pollution effect is reduced greatly if not totally eliminated. Energy engineering requires a "systematic approach" that is multidisciplinary in nature. Thus an energy engineer must have both skills in electrical, mechanical, process engineering as well as good management knowledge [13].In this wise energy saving, energy efficiency and renewable energies are the tool of choice for population centers to protect the climate, boost the regional economy and become independent of foreign oil and gas suppliers. Improving energy efficiency worldwide is the fastest, the most sustainable and the cheapest way to reduce greenhouse gas emission and enhance energy security in line with G8 summit Declaration of June 2007 [17]. Global Energy Security as a result of high and highly volatile energy prices have moved it, to the top of nations political agenda, hence one of the subjects of the summit of the G8 leaders in July 2006. Energy security rests on two principles namely: improvising energy efficiency and having access to technologies (and fuels) and encompasses supply side and demand side options. Thus the strong nexus between energy production use and human development. Energy in security differs within Africa, the situation differs dramatically between rural and urban regions as well as between Northern, Sub-Sahara and South Africa [17].

3.0 ENERGY AND ECONOMIC ISSUE.

Early on we related the technological development of a nation with the GNP and per capital energy consumption. In this section we looked at how the existence of markets policies, pertinent regulation (governmental policies, taxation), and adequate organization (trade quotas etc.) are important parts of the economics of energy. The economics of energy available at a particular time in a society is influenced greatly by the allocation of the scare energy resources and control of this energy. The model shown in Figure 3 illustrates relationship of social process like energy, economy, environment and political interventions of an industrialized nation [11]. In theory the market place balances all these factors and yields an equilibrium of supply and demand by means of tariffs and controls. As the world's energy market place changes a redistribution of economic wealth occurs, while the impact of energy and economics is felt in unemployment, GNP, inflation and trade and also that the income elasticity is somewhat related to the nations stage of economic developments among other factors [1].

A quantitative study of the relationship of energy consumption to GNP of a nation can be computed using the expression [1, 18]:

$$\text{Log } E = a + b\text{LogGNP} \quad (5)$$

Where,

E; energy consumption in millions of metrictons

b; the income elasticity; and R^2; correlation coefficient

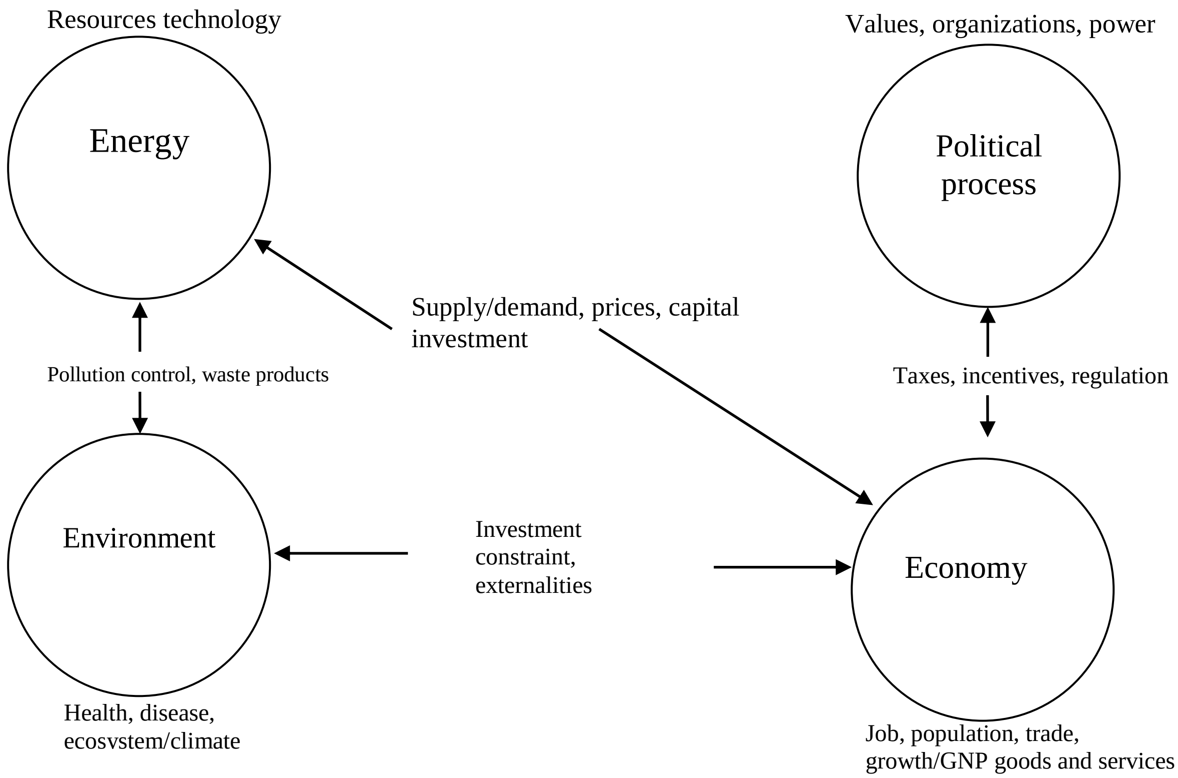

Figure 3: A model of the interactions of the social processes in an industrialized nation.

Energy inputs into goods or commodity and services such as electricity is known to be as much as 45%, suggesting that any major saving in this area not only reduces the production cost, but makes electricity and services more competitive locally and within the borderless world[6]. Hence energy is principally used as an input to an economic process and as an intermediate good. When energy is exchanged, it has a price per unit [1].

To buttress the essence of energy investment cost, a knowledge of life-cycle cost is critical. The life-cycle cost analysis using either the annual cost, present worth and rate of return analysis; evaluates the total owning and operating costs which accounts for the "time-value" of money and can incorporate fuel cost escalation into the economic. The cash flow model that illustrates the effect of "compound" of interest payment in the energy systems is [13]:

$$P = \left(\frac{1}{(1+i)^n}\right)s \tag{6}$$

Where,

P; present sum or value

i; interest rate earned at the end of each interest period

n; number of interest period

S; future sum or value

$(1 + i)^n$; "single payment compound amount" factor

4.0ENVIRONMENTAL IMPACTS OR EFFECTS.

The quality in environmental consciousness or rather frantical awareness on environmental issues is one of the elements that steam the era of change[6] that must be given due attention in energy engineering; The process of making water, air, soil etc. dangerously dirty and not suitable for people to use, or the state being dangerously dirty or rather the natural features of a place e.g. its weather, the type of land it has, and the type of plants that grow in it (habitat: a forest environment) constitute environmental impacts[14]. In this-wise environmental problems include, fossil fuels (greenhouse gases) and global warming, human, agricultural (intensive farming) and industrial waste, acid rain, air pollution from transport systems and industries, products harmful to the environment. Environmental pollution results from increasing population, population crowding, increasing affluence, and inefficiency in controlling the effluent or residues from the energy commission-consuming process. Dynamic societies have direct relation with traffic and congestion contributing environmental pollution such as air pollution, noise pollution, health hazard, traffic accidents and injuries, constrain economic productivity and degrades the quality of lives[6].

Energy inputs always produce some measure of pollution, since waste products occur along with the desired goods [1]. The annual percentage increase in pollution concentration in an industrialized nation is approximately equal to the sum of the annual percentage increase in pollution, GNP per capital, and the generating stations (plants) inefficiency. The ground level population concentration of $(So_2 + No_2 + CO_2 + radioactive\ waste + \ waste\ heat + \ etc.)$ causing say temperature rise in water bodies is expressed as[1]:

$$C_p \propto \left(\frac{N}{A}\right) \times G_{CW} \times t_{1/2} \times \frac{1}{e} \quad (7)$$

Where,

$\left({}^{N}/_{A}\right)$; the number of persons per area

G_{CW}; percapital total consumption and wastage of energy or goods or the Gross National Product per capita

$t_{1/2}$; half-life of the pollutant in the environment in year

e; efficiency of cleaning up the effluent from the energy – consumption process. If the clean-up of the effluent is perfect, then $e = \infty$ and we have C_p=0, if also $G_{CW} \equiv GNP$, since consumption is almost linearly related to GNP per capita:

$$G_{CW} \propto F \quad (8)$$

Where, F is the amount of fuel or energy source consumed per capita to produce the goods or electric energy.

If we define $\mu = \frac{F_0}{F}$ (9)

Where, F_0 is the theoretical minimum energy per capital required to produce the goods or energy we get:

$$G_{CW} \propto {}^{F_0}/_{\mu} \quad (10)$$

Hence, equation 7 becomes:

$$C_P = \left(\frac{N}{A}\right) \times \frac{F_0}{\mu} \times t_{1/2} \times \frac{1}{e} \quad (11)$$

Meaning the pollutant concentration is proportional to the product of the concentration of people per sq. km, the goods consumed per head, and how long the pollutant survives before the environment copes with it, divided by the energy (fuel) efficiency and the effluent-cleaning efficiency. Also in 1997, the world released 23.9 billion metric tons of carbon dioxide, almost half of it from high-income countries [1].

To control pollution concentration, which entails: renewable/sustainable energy resources, recycling, environmentally friendly transport, organic farming (biodegradable), ozone-friendly products, renewable resources. the following statutory methods are employed; 1) Reduce the population density; 2) Reduce per capital consumption; 3) Increase the efficiency of the energy conversion process and 4) Increase the effectiveness of cleaning up the pollution. These could include flue-gas desulfurization, building tall smoke stacks, and burning low sulfur fuel, construction cooling towers and ponds etc.

Table 7 presents comparison of adverse effects on ten environmental parameters and characteristics of hydro, nuclear and fossil-fuel power plant. Comparing the various method of power generation, hydro-electric schemes is one more reliable, durable and best economic alternative to fossil-fuel or nuclear power plant. It has also from economic point of view that the cost of constructing a tidal- power plant may be approximately $800 per installed kilowatt for a nuclear plant or $500 perkilowatt for fossil- fuel plants.

Table 7: Comparison of Adverse Effects on Ten Environmental Parameters and Characteristics of Hydro, Nuclear and Fossil-Fuel Power Plant.

Adverse effects/characteristics	**Hydro schemes**	**Nuclei or fission reactors**	**Fossil-fuel steam electric**
Land use impact	Greatest effect	Great effect	Least effect
Major review on irrigation and recreation area	Yes	No	No
Capital lost/kw	Higher than fossil-fuel	Higher than fossil-fuel plant and lower than hydro scheme	Lower
Operating cost	Very small	Maybe lower than hydro scheme	Relatively high
Technology	Well developed and proven	Available	Well developed and proven
Economic life	50-100 years	Inexhaustible	Depends on resource availability
Thermal pollution	No	Yes (i.e. 65% heat rejection)	Yes (i.e. 60% heat rejection)
Air pollution (i.e. carbon monoxide, sulfur dioxides, hydro carbon and particulate matters)	No	Yes	Yes
Radioactive waste	No	Yes (high or low)	No
Consumes natural resources	No	Yes	Yes
Sensitivity to earth quakes (seismicity)	Moderate	Greatest	Least
Quantity of raw material/Kw	Highest	Least	Great effect
Other natural hazards (extreme weather conditions or flood)	Great effect	Highest	Least
Industrial hazards (aircraft crash should transport and storage of hazardous materials	Least	Greatest	Moderate
Population distribution	Moderate	Greatest effect	Least
Noise pollutants above 35decibel that result in physiological and psychological to human beings in the environment	Least	Moderate	Greatest effect

It is important to point out, in radioactive radiation the maximum integrated dose for a person of age A years is (A-18) ×5rem[1]. Table 8 presents the effect of radioactive radiation exposure to human body. The tolerance of the body skin to radioactive radiation depends on the following variables: 1) Degree of retention of radioactive material in the body; 2) The fraction of the radioactive material when is passed to the critical tissues by the blood stream; 3) The radio sensitivity of the tissues involved e.g. bone, lymph glands, ovaries; testes are more vulnerable to energetic radiation; 4) Sized of organ involved; 5) Essentiality of organ and 6) Type of radiation.

Table 8: Effect of Radiation on the Body

Description	Dose (rem)
Amount which is detectable	25
Radiation sickness in 50% of exposed	500
Eventual death in 50% of exposed	450
Certain death in 24 hours	600-1,000
Death in few hours	1,000

5.0 SOCIOECONOMIC EFFECTS

The socioeconomic effects resulting from constructing power stations, occurs in two stages; the construction stage entails:1) Moving materials and plant required by road; 2) Moving workers to and from the site during construction; 3) Providing accommodations, social amenities etc.; 4) Establishing the availability and suitability of local skilled and unskilled labour. While long term socioeconomic effects of an operating power stationsconcern:1) Housing demands; 2)Travel patterns;3) Expenditure/revenue distribution; and4) Effect on local employers [11].

The construction of power stations of all types, the effects of the development on tourism and recreation attracts visitors, preserve existing facilities and enhance them; the creation at various station of nature resources, field study centers, bird sanctuaries, the licensing of fishing facilities and the establishment of fish farms for re-stocking purposes, as distinct from the commercial fish farms making use of warmed clothing water discharges. Figure 4 illustrates the authoritywith whom generation board/authorities consults on the local impacts of power station to contribute and comment [11].

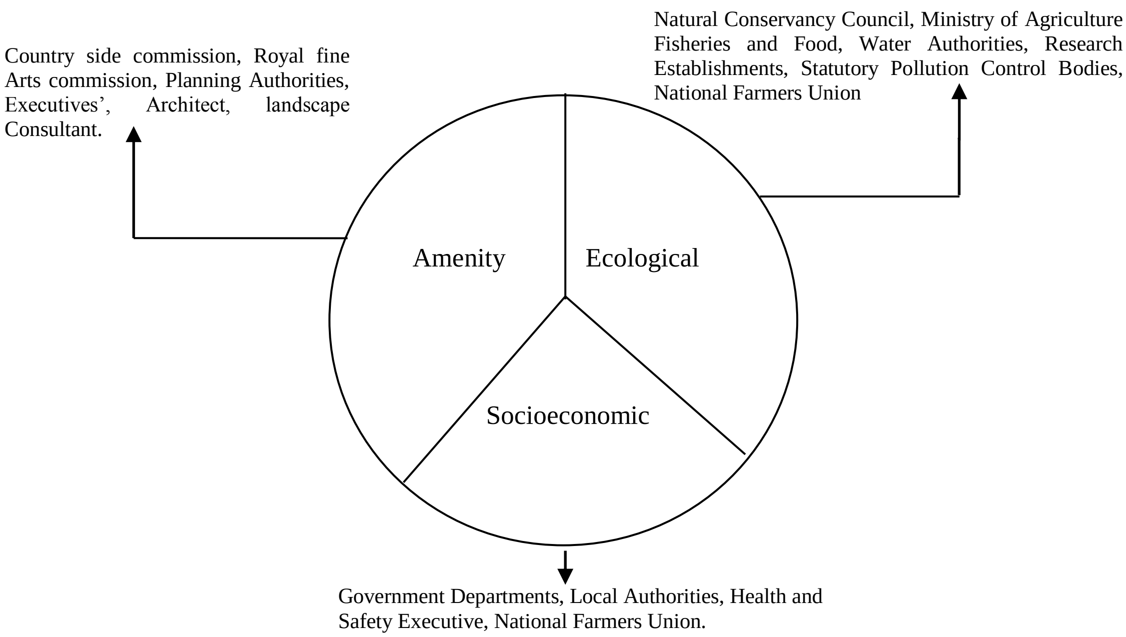

Figure 4: Consultations on local environment impacts.

6.0 CONCLUSION

In this study we presented a typical total energy system that uses any form of conventional energy resources as input and established that the energy rejected wastes in electricity generation as end products can be recombined in processes to yield other useful energies to improve the overall efficiency from 70-80% against the attendant 35-45% of utilities plant. The environmental effects and consequences presented from the three conventional plants used to power nations base load and meet up with the period peak-load demand and the mitigating measures are in tandem with standard world practices. The consumption of energy per capita and the Gross National Product (GNP) index values is a measure of nations development and standard of living. Thus the nation's Gross Domestic Product (GDP) and Gross National Product (GNP) indices presented in the study calls for the nation's energy regulatory bodies and authority urgent move to attend to the energy crisis in the country in older to drive the socioeconomic and industrial revolution into a developed nation.

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